Conclusion

Applicants believe they have addressed all of the Examiner's concerns and placed the application in condition for allowance. If for any reason the Examiner finds the application other than in condition for allowance, and the Examiner believes that a teleconference may be helpful, the Examiner is invited to call the undersigned attorney at (818) 883-5055 to discuss the steps necessary for placing the application in condition for allowance.

Respectfully submitted,

10/15/03
Date

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In the Specification:

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Figure 19a shows the physician's remote controller that has the same functionality inside as the physician's controller but with the addition of communication means such as telemetry or telephone modem;

Figure 19b shows an alternate embodiment of the physician's remote controller implemented by a standard notebook PC.

Figure 19c shows an alternate embodiment of the physician's remote controller implemented by a standard desktop PC.

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An external imager (111) sends an image in the form of electrical signals to the video data processing unit (113). The video data processing unit consists of microprocessor CPU's and associated processing chips including high-speed data signal processing (DSP) chips. This unit can format a grid-like or pixel-like pattern that is sent to the electrodes by way of the telemetry communication subsystems, external telemetry unit (118), and internal telemetry unit in internal implant (121). See Figure 1b. In this embodiment of the retinal color prosthesis ~~(Fig. 1b, (121))~~, these electrodes are incorporated in the internal ~~to the eye~~ implant~~ed part~~121.

These electrodes, which are part of the internal implant (121), together with the telemetry circuitry~~(121)~~ are inside the eye. With other internally implanted electronic circuitry ~~(121)~~, they cooperate with the electrodes so as to replicate the incoming pattern, in a useable form, for stimulation of the retina so as to reproduce a facsimile perception of the external scene. The eye-motion (112) and head-motion (131) detectors supply information to the video data processing unit (113) to shift the image presented to the retina (120).

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Logarithmic encoding of light

In one aspect of an embodiment (Figure 1b), light amplitude is recorded by the external imager (111) . The video data processing unit using a logarithmic encoding scheme (113) to convert the incoming light amplitudes into the logarithmic electrical signals of these amplitudes (113). These electrical signals are then passed on by external telemetry unit (118), (121), to the internal telemetry unit in internal implant (121) which results in the retinal cells (120) being stimulated via the implanted electrodes in internal implant (121), in this embodiment as part of the internal implant (121). Encoding is done outside the eye, but may be done internal to the eye, with a sufficient internal computational capability.

Energy and signal transmission

Coils

The retinal prosthesis system contains a color imager (Figure 1b, 111) such as a color CCD or CMOS video camera. The imaging output data is typically processed (113) into a pixel-based format compatible with the resolution of the implanted system. This processed data (113) is then associated with corresponding electrodes and amplitude and pulse-width and frequency information is sent by telemetry (118) into the internal unit coils, (311), (313), (314) (see Figure 3a). Electromagnetic energy, is transferred into and out from an electronic component (311) located internally in the eye (312), using two insulated coils, both located under the conjunctiva of the eye with one free end of one coil (313) joined to one free end of ~~the~~ a second coil (314), the second free end of said one coil (313) joined to the second free end of said second coil (314). The second coil (314) is located in proximity to an internal coil (311) which is a part of said internally located electronic component, or, directly to said internally located electronic component ~~(311)~~. The larger coil is positioned near the lens of the eye. Said one coil, ~~T~~the larger coil, is fastened in place in its position near the lens of the eye, for example, by suturing. Figure 3b represents an embodiment of the telemetry unit temporally located near the eye, including an ~~external temporal~~ primary coil (321), an internal (to the eye) coil (312), an external-to-the-eye electronic chip (320), dual coil transfer units (314, 323), (321,322) and an internal-to-the-eye electrode array (325). The advantage of locating the external electronics in the fatty tissue behind the eye is that there is a reasonable amount of space there for the electronics and in that position it appears not to interfere with the motion of the eye.

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Said elongated electrodes in an aspect of this of an embodiment of this invention may be of all the same length. In a different aspect of an embodiment, they may be of different lengths. Said electrodes may be of varying lengths (Figure 8b and 8c, ~~820~~818), such that the overall shape of said electrode group conforms to the curvature of the retina (814). In either of these cases, each may penetrate the retina from an epiretinal position (Figure 8a, 811), or, in a different aspect of an embodiment of this invention, each may penetrate the retina from a subretinal position (Figure 9b, 817).

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Platinum electrodes

Figure 11 (a-e) demonstrates a preferred structure of, and method of, making, spiked and mushroom platinum electrodes. Examining Figure 11a one sees that the support for the flat electrode (11093) and other components such as electronic circuits (not shown) is the silicon substrate (1101). An aluminum pad (1102) is placed where an electrode or other component is to be placed (1102). In order to hermetically seal-off the aluminum and silicon from any contact with biological activity, a metal foil (1103), such as platinum or iridium, is applied to the aluminum pad (1102) using conductive adhesive (1104). Electroplating is not used since a layer formed by electroplating, in the range of the required thinness, has small-scale defects or holes which destroy the hermetic character of the layer. A titanium ring (1105) is next placed on the ~~platinum or iridium~~ metal foil (1103). Normally, this placement is by ion implantation, sputtering or ion beam assisted deposition (IBAD) methods. Silicon carbide, diamond-like coating, silicon nitride and silicon oxide in combination, titanium oxide, tantalum oxide, aluminum nitride, aluminum oxide or zirconium oxide (1106) is placed on the silicon substrate (1101) and the titanium ring (1105). In one embodiment, an aluminum layer (1107) is plated onto exposed parts of the titanium ring (1105) and onto the silicon carbide, diamond-like coating, silicon nitride and silicon oxide in combination, titanium oxide, tantalum oxide, aluminum nitride, aluminum oxide or zirconium oxide (1106). In this embodiment the aluminum (1107) layer acts as an electrical conductor. A mask (1108) is placed over the aluminum layer (1107).

In forming an elongated, non-flat, electrode platinum (Figure 11b) is electroplated onto the ~~platinum or iridium~~ metal foil (1103). Subsequently, the mask (1108) is removed and insulation (1110) is applied over the platinum electrode (1109).

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Inductive coupling coils

Information transmitted electromagnetically into or out of the implanted retinal color prosthesis utilizes insulated conducting coils so as to allow for inductive energy and signal coupling. Figure 12 shows an insulated conducting coil and insulated conducting electrical pathways, e.g., wires, attached to substrates at what would otherwise be electrode nodes, with flat, recessed metallic, conductive electrodes (1201). In referring to wire or wires, insulated conducting electrical pathways are included, such as in a "two-dimensional" "on-chip" coil or a "two-dimensional" coil on a polymide substrate, and the leads to and from these "two-dimensional" coil structures. A silicon carbide, diamond-like coating, silicon nitride and silicon oxide in combination, titanium oxide, tantalum oxide, aluminum nitride, aluminum oxide or zirconium oxide (1204) is shown acting as both an insulator and a hermetic seal. Another aspect of the embodiment is shown in Figure 12a. The electrode array unit (1201) and the electronic circuitry unit (1202) can be on one substrate, or they may be on separate substrates ~~(1202)~~ joined by an insulated wire or by a plurality of insulated wires (1203). Said separate substrate units can be relatively near one another. For example they might lie against a retinal surface, either epiretinally or subretinally placed. Two substrates units connected by insulated wires may carry more electrodes than if only one substrate with electrodes was employed, or it might be arranged with one substrate carrying the electrodes, the other the electronic circuitry. Another arrangement has the electrode substrate or substrates placed in a position to stimulate the retinal cells, while the electronics are located closer to the lens of the eye to avoid heating the sensitive retinal tissue.

In all of the Figures 12a, 12b, and 12~~e~~d, a coil (1205) is shown attached by an insulated wire. The coil can be a coil of wire, or it can be a "two dimensional" trace as an "on-chip" component or as a component on polyimide. This coil can provide a stronger electromagnetic coupling to an outside-the-eye source of power and of signals. Figure 12d shows an externally placed aluminum (conductive) trace instead of the electrically conducting wire of Figure 12c. Also shown is an electrically insulating adhesive (1208) which prevents electrical contact between the substrates (1202) carrying active circuitry (1209), except where connected by aluminum trace (1207).

In the Drawings:

Please replace Figures 1b, 2a, 3d, 4, 6c, 8c, 12 and 20 with the enclosed replacement drawings.

In the Claims:

269. (Currently Amended) A visual prosthesis comprising:

an internal electronics unit, ~~implanted~~ suitable for implantation within a living body, at least a portion of said internal electronics unit is formed within a biocompatible hermetic package; and

a plurality of electrodes driven by said internal electronics unit suitable for stimulating visual neurons to create a perception of a visual image.

270. (Previously Presented) The visual prosthesis according to claim 269, wherein said biocompatible hermetic package is a hermetic box.

271. (Previously Presented) The visual prosthesis according to claim 270, wherein said hermetic box includes a metal portion and a ceramic portion.

272. (Currently Amended) The visual prosthesis according to claim 271, ~~wherein said metal portion is braised to said ceramic portion~~further comprising a braised joint between said metal portion and said ceramic portion.

273. (Currently Amended) The visual prosthesis according to claim ~~269~~271, further comprising a flip chip electrically connected to feed throughs in ~~a~~ said ceramic portion.

274. (Currently Amended) The visual prosthesis according to claim ~~271, wherein said metal portion includes a metal ring braised to said ceramic portion and a metal lid welded to said metal ring~~271, wherein said metal portion comprises a metal sidewall joined with a metal top by a weld joint.

275. (Withdrawn) The visual prosthesis according to claim 269, wherein said biocompatible hermetic package is a thin film.

276. (Previously Presented) The visual prosthesis according to claim 269, wherein said biocompatible hermetic package is partially a thin film and partially a hermetic box.

277. (Currently Amended) The visual prosthesis according to claim ~~275~~1, wherein said biocompatible hermetic package is a thin film ~~is a~~ diamond coating.

278. (Withdrawn) The visual prosthesis according to claim 275, wherein said thin film is aluminum oxide.

279. (Withdrawn) The visual prosthesis according to claim 275, wherein said thin film is zirconium oxide.

280. (Withdrawn) The visual prosthesis according to claim 275, wherein said thin film is selected from the group consisting of titanium oxide, tantalum oxide and aluminum nitride.

281. (Withdrawn) The visual prosthesis according to claim 275, wherein said thin film is selected from the group consisting silicon oxide, silicon nitride, and silicon carbide.

282. (Withdrawn) The visual prosthesis according to claim 275, wherein said thin film is applied by ion-beam assisted deposition.

283. (Currently Amended) A visual prosthesis comprising:

a plurality of electrodes suitable for stimulating a retina; and

an internal electronics device controlling said plurality of electrodes and ~~positioned~~ suitable for positioning within a vitreous humor, but distant from a retina.

284. (Currently Amended) The visual prosthesis according to claim 283, wherein said internal electronics device is suitable to be positioned in the center of the vitreous humor.

285. (Currently Amended) The visual prosthesis according to claim 283, further comprising a thin film hermetic diamond like coating applied to said internal electronics device.

286. (Withdrawn) The visual prosthesis according to claim 285, wherein said thin film is a diamond like coating.

287. (Withdrawn) The visual prosthesis according to claim 285, wherein said thin film is aluminum oxide.

288. (Withdrawn) The visual prosthesis according to claim 285, wherein said thin film is zirconium oxide.

289. (Currently Amended) A visual prosthesis comprising:

an internal electronics unit, ~~implanted~~ suitable for implantation within a living body in the vicinity of an eye, at least a portion of said internal electronics unit is formed within a biocompatible hermetic package; and

a plurality of electrodes driven by said internal electronics unit suitable for stimulating a retina to create a perception of a visual image.

290. (Currently Amended) The visual prosthesis according to claim ~~269~~289, wherein said biocompatible hermetic package is a hermetic box.

291. (Previously Presented) The visual prosthesis according to claim 290, wherein said hermetic box includes a metal portion and a ceramic portion.

292. (Currently Amended) The visual prosthesis according to claim 291, ~~wherein said metal portion is braised to said ceramic portion~~further comprising a braised joint between said metal portion and said ceramic portion.

293. (Currently Amended) The visual prosthesis according to claim ~~289~~290, further comprising a flip chip electrically connected to feed throughs in ~~a~~ said ceramic portion.

294. (Currently Amended) The visual prosthesis according to claim ~~291, wherein said metal portion includes a metal ring braised to said ceramic portion and a metal lid welded to said metal ring.~~ 291, wherein said metal portion comprises a metal ring joined with a metal top by a weld joint.

295. (Currently) The visual prosthesis according to claim 289, wherein said biocompatible hermetic package is a diamond like thin film.

296. (Previously Presented) The visual prosthesis according to claim 289, wherein said biocompatible hermetic package is partially a thin film and partially a hermetic box.

297. (Withdrawn) The visual prosthesis according to claim 295, wherein said thin film is a diamond coating.

298. (Withdrawn) The visual prosthesis according to claim 295, wherein said thin film is aluminum oxide.

299. (Withdrawn) The visual prosthesis according to claim 295, wherein said thin film is zirconium oxide.

300. (Withdrawn) The visual prosthesis according to claim 295, wherein said thin film is selected from the group consisting of titanium oxide, tantalum oxide and aluminum nitride.

301. (Withdrawn) The visual prosthesis according to claim 295, wherein said thin film is selected from the group consisting silicon oxide, silicon nitride, and silicon carbide.

302. (Withdrawn) The visual prosthesis according to claim 295, wherein said thin film is applied by ion-beam assisted deposition.

303. (Withdrawn) An implantable device comprising:
a ceramic substrate having feed throughs; and
active electronics supported by said ceramic substrate and electrically coupled to said feed throughs.

304. (Withdrawn) The implantable device according to claim 303, wherein said active electronics is an integrated circuit.

305. (Withdrawn) The implantable device according to claim 303, further comprising a hermetic package wherein said ceramic substrate forms part of said hermetic package.

306. (Withdrawn) The implantable device according to claim 303, wherein said implantable device is part of a visual prosthesis.

307. (Withdrawn) The implantable device according to claim 306, wherein said visual prosthesis is a retinal prosthesis.

308. (Withdrawn) The implantable device according to claim 303, wherein a side of said ceramic substrate opposite said active electronics is adapted to contact tissue.

309. (Withdrawn) An implantable device comprising:
a ceramic substrate having feed throughs;

a plurality of capacitors electrically coupled to said feed throughs and supported by said ceramic substrate; and

active electronics electrically coupled to said plurality of capacitors.

310. (New) A method of making an implantable device comprising:

making an electronics circuit suitable for stimulating neural tissue;

coating said electronic circuit with a ceramic by ion-beam assisted deposition; and

electrically coupling electrodes to said electronic circuit.

311. (New) The method according to claim 310, wherein said step of coating comprises coating with aluminum oxide.

312. (New) The method according to claim 310, wherein said step of coating comprises coating with zirconium oxide.

313. (New) The method according to claim 310, wherein said step of coating comprises coating with a material selected from the group consisting of titanium oxide, tantalum oxide and aluminum nitride.

314. (New) The method according to claim 310, wherein said step of coating comprises coating with a material selected from the group consisting silicon nitride, and silicon carbide.